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DRAWINGS ATTACHED

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(54) PROTECTIVE ENCLOSURE FOR A SUBSEA WELLHEAD APPARATUS

(71) We, ACF INDUSTRIES INCORPORATED, a Corporation organised and existing under the Laws of the State of New Jersey, United States of America, of 750 Third Avenue, New York 17, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the the following statement:—

This invention relates to a protective enclosure for a subsea wellhead apparatus, and has for its object to provide such an enclosure in a simple and convenient form.

According to the invention a protective encloure for a subsea wellhead apparatus comprises a housing of hollow cylindrical form and having a bottom end wall, a conductor guide casing secured to said end wall and a plurality of drag blades secured to the external surface of said end wall whereby when the enclosure is lowered into position in the sea bed, the enclosure may be moved so that the blades agitate the stratum of the sea bed to facilitate the positioning of the enclosure therein.

In the accompanying drawings:—

Figure 1 is a sectional view of one example of a low profile subsea wellhead enclosure structure in accordance with the invention and having a wellhead mechanism located therein and shown in elevation,

Figure 2 is a sectional view of the protective enclosure of Figure 1 having the cover removed and illustrating washing the enclosure into place,

Figure 3 is a sectional view of the protective enclosure of Figure 1 illustrating the enclosure in place within the surface stratum of the ocean floor and showing landing of the surface casing,

Figure 4 is a part sectional view in elevation illustrating the protective enclosure of this invention and showing installation of a wellhead assembly and Christmas tree assembly therein,

Figure 5 is an elevational view illustrating the profile of the enclosure,

Figure 6 is a fragmentary sectional view of part of the cover structure of the protective enclosure,

Figure 7 is a fragmentary sectional view of the part of the cover structure shown in Figure 6 and illustrating the stabbing pin arrangement utilised for filling the enclosure with preservative fluid,

Figure 8 is a view similar to Figure 7 showing an alternative arrangement of the stabbing pin,

Figure 9 is a fragmentary sectional view of the part of the cover structure of Figure 6 showing the mounting of a pressure balancing closure member,

Figure 10 is an elevational view illustrating a repair manipulator for use within the enclosure,

Figure 11 is a sectional view of the enclosure showing the manipulator installed in an operating position and,

Figure 12 is a plan view illustrating the repair manipulator structure of Figure 10.

With reference to the drawings for a better understanding of the invention, in Figure 1, there is shown a generally cylindrical protective housing 10 having a generally cylindrical side wall 12, an upper frusto-conical bottom wall 13 and a lower frusto-conical bottom wall 14, which are interconnected by a small cylindrical wall 15. The bottom wall 14 is connected by welding or the like to a conductor guide casing 16 of tubular construction which extends a considerable depth below the protective housing 10. For example, the conductor guide assembly may be in the order of 200 feet in length. The bottom of the conductor guide casing is rounded as illustrated in Figure 2 and is provided with one or more openings 18 through which pressurised fluid such as water may flow as the conductor guide casing and the protective housing are washed into place as described in detail hereinbelow. A number of ribs or drag blades 20 and 21 are fixed to the exterior of the bottom walls 13 and 14 respectively, to serve both to strengthen the walls during service conditions of the protective housing and to agitate the surface stratum as the protective housing and conductor guide mechanism are washed to

their proper position. A plurality of centering elements 22 are provided either interiorly of the conductor guide casing 16 or exteriorly of a centering sleeve structure 24, receivable within the conductor guide casing. The purpose of the centering sleeve is to properly orient drill pipe or stem 26 and other conduit structure which might extend through the conductor guide casing. Obviously, a separate centering sleeve is required for any particular size of drill stem or casing extending through the conductor guide casing.

For the purpose of washing the protective housing and the conductor guide casing to the proper depth with respect to the surface stratum, the drill pipe 26 extends through the centering sleeve 24 and is disposed in fluid communication with the jet opening 18 at the bottom of the conductor guide casing 16 in such manner as to force pressurised fluid outwardly through the jet opening 18. The drill pipe 26 is connected to suitable fluid pressurising apparatus such as pump structure located on a drilling vessel or platform capable of forcing high pressure fluid, such as water, outwardly through the jet opening 18, in order to wash away the surface stratum and allow the conductor guide casing to settle into the void defined by the displaced stratum. After the conductor guide casing 16 is completely inserted into the surface stratum the substantially larger protective housing 10 will begin to enter into the surface stratum as washing is continued. Pressurised fluid pumped through the jet opening 18 will continue to circulate about the conductor guide casing 16 and protective housing 10 and will wash away the surface stratum under protective housing allowing the housing also to settle within the surface stratum. In the event agitation of the surface stratum is necessary to achieve the washing operation, the protective housing and the conductor guide casing attached thereto may be rotated, thereby to cause the drag blades 20 and 21 to erode away the surface stratum allowing the circulating fluid to carry the displaced material to the surface of the ocean floor.

The conductor guide casing 16 and the protective housing 10 are lowered as a unit into the surface stratum of the ocean until a landing flange 28, fixed about the cylindrical wall 12, is lowered into engagement with the surface of the ocean floor. The conductor guide casing 16 and the attached protective housing 10 are then cemented into place by circulating cement through the drill stem 26 and outwardly around the housing. In the event the surface stratum is of sufficient hardness that washing the housing to its proper depth is impractical, it is obvious that a hole may be drilled to proper depth and then may be reamed to proper configuration to receive the guide conductor and housing.

For the purpose of guiding various operating tools and well drilling equipment into properly oriented relation with the protective housing, guide posts 30 are secured to the exterior of the cylindrical wall 12 by welding or the like. Guide cables 32 extend upwardly from the guide posts 30 to the drilling vessel or platform performing the drilling operation. A guide frame 34 is adapted to travel on the cables 32 upwardly and downwardly relative to the protective housing and serves to guide various tools and equipment into proper assembly with the protective housing. The guide frame 34 includes guide receptacles 36 received by the guide posts 30 as the guide frame is lowered into proper assembly with the protective housing. The guide receptacles 36 are provided with apertures 38 receiving the cables 32 in guiding relation therewith.

During the sinking of the housing and guide casing a temporary extension sleeve 40 is attached to the upper extremity of the cylindrical wall 12 to serve as a barrier during the sinking and subsequent drilling operations to prevent sand or other foreign matter from the ocean floor from entering the interior of the protective housing. The upper portion of the well is drilled and a surface casing 42 is landed on the upper portion of the centering guide 22 and is cemented into place. At the upper portion of the surface casing 42 is located a casing hanger shoulder 44 provided for landing and orienting other casing and tubing in telescoping relation with the surface casing Obviously, any other acceptable casing, tubing and wellhead arrangement may be employed.

As shown in Figure 4, the well is completed by the installation of a wellhead assembly illustrated generally at 46 including a wellhead mechanism 48, a Christmas tree assembly 50 and a valve control system 52 for selectively operating the valves of the Christmas tree assembly 50. The temporary extension sleeve 40 is removed prior to installation of the wellhead assembly within the protective housing 10. The Christmas tree 50 includes a plurality of valves 54, each being actuated by a remotely controllable power operator to control the flow of fluid through the Christmas tree production conduit structure. Hydraulic power may be provided for controlling the various hydraulic valve operators by the self-contained hydraulic power pack 52, or other conventional valve actuation means may be incorporated into the wellhead assembly.

The well head assembly is provided with at least one production conduit 58 extending from the Christmas tree 50 to an appropriate storage or fluid handling facility for

petroleum products being produced by the well. A generally cylindrical permanent extension 60 is connected in sealed engagement to the upper extremity of the cylindrical wall 12 and provides for sealed extension of the production conduit through the protective housing 10. The extension 60 is permanently welded or otherwise fixed to the production conduit before installation of the wellhead assembly and is lowered into assembly with the cylindrical wall 12 along with the Christmas tree assembly. This feature prevents any necessity for providing an opening in the enclosure wall which must be sealed about the production flow conduit after the conduit is installed.

Connection between sections of the production conduit 58 may be established by means of remotely actuated flow line connectors, such as illustrated at 62 in Figure 4. Various connections between the Christmas tree structure 50 and other structure of the wellhead assembly 46 may be accomplished by any one of a number of acceptable remotely actuated connector devices, thereby allowing the Christmas tree assembly to be removed or installed without any necessity for providing diver assistance to accomplish the same.

After the well has been completed and the wellhead assembly has been installed, a protective cover structure 64 is lowered by the guide frame 34 into sealed assembly with the upper portion of the extension sleeve 60. A fluid transfer connection 66 is fixed to the protective cover 64 and comprises a stabbing sleeve 67 welded or otherwise fixed to the cover structure 64. The fluid transfer connection structure is employed to fill the protective housing with a preservative substance including corrosion inhibitors and agents to prevent the growth of marine life. The same fluid transfer connection structure is employed to remove the preservative substance from the protective enclosure simply by changing internal fluid passage structure of the fluid transfer structure by means of threaded plugs as will be described in detail hereinbelow. The stabbing sleeve 67 is provided with a through passage 68 having a pair of internal cylindrical surfaces 69 and 70 providing sealing surfaces for engagement by a pair of spaced sealing members 71 and 72, respectively, carried by a stabbing pin 73 receivable within the sleeve 67. The sleeve 67 is also provided with internal threads 74 at the upper extremity thereof for receiving a closure plug as illustrated in Figure 9. If desired, the stabbing pin may also be provided with external threads received by the internal threads 74 in order to establish a secure connection between the stem 26 and the cover structure 64. The stabbing pin 73 is provided with an upper internally threaded blind depression 76 to which the drill stem 26 is threadedly connected as shown in Figures 7 and 8. A pair of generally parallel fluid transfer passages 77 and 78 are formed in the stabbing pin 73 and are disposed in fluid communication with the depression 76. Passage 77 extends substantially straight through the stabbing pin and terminates at the bottom of the pin in order to conduct fluid directly between the protective enclosure and the drill stem 26. The passage 77 is threaded at its upper extremity in order to receive a threaded plug 79 as shown in Figure 7. A transverse passage 80 communicates passage 77 with the atmosphere or with the medium surrounding the stabbing stem and is internally threaded at its outer extremity for the purpose of receiving a closure plug. The passage 78 is communicated to the medium surrounding the stabbing pin or to a return conduit 81 through a transverse passage 82 also being threaded at its outer extremity in order to receive a closure plug such as is shown in Figure 7 or to receive a return conduit as illustrated in Figure 8. Passage 78 is also communicated by another transverse passage 83 with an annular chamber 84 defined about the pin 73 due to the different diameter of the surfaces 69 and 70. A displacement conduit 85 is welded or otherwise fixed to the stabbing sleeve 67 and establishes fluid communication with the annular chamber 84. A conduit 85 is connected with a second displacement conduit 86 Figure 5 fixed outwardly of the protective housing 10 by a remotely controlled connection mechanism 87.

If desired, the stabbing sleeve can be fixed at a lower point to the cover 64 or may be manufactured slightly longer in order to allow the displacement conduit shown in broken lines at 88 to be located within the protective housing 10 when the protective housing is closed by the cover structure 64. In such case, the displacement conduit is installed and removed simultaneously with installation and removal of the cover 34 and an automatic connection structure is not required.

With reference now to Figure 7, for the purpose of filling the protective housing 10 with a fluid substance containing corrosion and marine life inhibitors and being heavier than water, the stabbing pin 73 is arranged with a closure plug 79 closing the upper extremity of the passage 77 and with a second closure plug closing the transverse outlet passage 82. The preservative fluid may be pumped from the platform through the drill stem 26 to the stabbing pin structure 73 where it will flow through passage 78 and transverse passage 83 to the displacement conduit structure 85 and 86. The preservative fluid will exit from the displacement conduits through the opening 87*a* at the lowermost portion of the protective housing,

and being heavier than seawater, will displace the seawater upperwardly causing seawater within the protective housing to exit through the passage 77 and the transverse outlet passage 80. If desired, a return conduit may be connected to the threaded portion of the transverse outlet passage 80 allowing the displaced seawater and preservative fluid to be transported to the platform for handling. Ordinarily, it is more appropriate to vent the seawater from the housing into the sea. After sufficient preservative fluid has been pumped into the protective enclosure to completely fill the same, a pressure balancing closure 89 may be threadedly received; within the upper extremity of the stabbing sleeve 67 essentially as illustrated in Figure 9. An annular sealing member 90 is carried at the lower extremity of the closure 89 and engages the sealing surface 69 of the stabbing pin 67 in order to establish a fluid passage seal between the closure and the stabbing pin.

In the event servicing of the subsea wellhead is required it will be necessary to remove the preservative fluid from the enclosure. This is accomplished by removing the closure plug and inserting pin 67. The upper extremity of the passage 78 is closed with a plug and the transverse outlet passage 80 is closed with a plug as shown in Figure 8. The outlet passage 82 may either be open to the medium surrounding the connection structure or a return conduit 81 may be connected as shown in Figure 8 in order to conduct displaced preservative fluid to the drilling platform or vessel. To displace the preservative fluid from the enclosure 10, water is pumped through the drill stem 26 and through the passage 77 into the upper extremity of the closure as shown by small flow arrows. This causes the preservative fluid within the enclosure 10 to be forced upwardly through the displacement conduits 86 and 85 and into the passage 78 of the stabbing pin 73. The preservative fluid may then be either displaced directly into the sea through the transverse outlet passage 82 or the fluid may be transported to the drilling platform through the return line 81 for storage and reuse.

Removal of the preservative fluid from the enclosure 10 may also be accomplished by removing the cover 34 and by simply pumping the preservative fluid out of the uncovered enclosure.

In the event the preservative substance is lighter than seawater, the filling and removing operations obviously will be substantially reversed.

For the purpose of balancing fluid pressure within the protective enclosure 10 at all times, the pressure balancing closure 89 is provided with a pair of fluid passages 91 and 92 each being provided with spring biased check valves 93 and 94, respectively. In the event the fluid pressure within the protective enclosure should increase above the hydrostatic pressure of the seawater surrounding the enclosure, the outlet check valve 94 will be displaced from its seat and fluid under pressure will bleed into the seawater. A reduction of the fluid pressure within the protective enclosure 10 below the hydrostatic head of the seawater will cause the inlet check valve 93 to be displaced from its seat allowing seawater to enter and balance the internal pressure. This feature allows the protective enclosure structure to be fabricated of relatively light material, since it is not subjected to great differential pressures.

After the drill pipe 26 has been disconnected from the fluid transfer connection structure 66 and the pressure balancing closure 89 has been installed, the extension 60 and protective cover 64 for the enclosure 10 will extend above the surface of the ocean floor essentially as illustrated in Figure 5. The production flow conduit 58 will exit from the protective enclosure near the level of the ocean floor, thereby precluding any tendency of the production flow conduit to be damaged by foreign objects. The low profile of the protective enclosure and the relation of the wellhead and Christmas tree to the ocean floor will minimise the possibility of injury to the subsea wellhead mechanism by objects moving through the ocean at the level of the ocean floor.

With reference now to Figures 10 and 11, for the purpose of repairing the valves of the Christmas tree assembly and for performing generally at 95, is lowered into the protective housing after the cover structure has been removed. The repair manipulator includes a vertical support column 96 receiving a work platform 97 in sliding engagement therewith. The work platform 97 is moved to any position along the length of the column 96 by a control cable 98. An electrically or hydraulically energised motor 99 is remotely controllable in order to raise or lower the work platform 97 to any suitable operating position thereof. The work platform 97 includes an extendable work shelf 100 carrying a valve operator manipulating device 102 or other suitable work apparatus. The work platform 97 also includes a power operated wrench 104 carried by the work shelf 100 which may be driven by hydraulic or electrical energisation as desired, and includes a drive socket 106 capable of engaging the drive nut 108 of a valve operator in the manner illustrated in Figure 10. The upper extremity of the manipulator is provided with support wheel structure 110 capable of engaging the uppermost portion of the extension 60 or enclosure rim essentially as shown in Figure 11. The support wheel structure 110 is driven by the

motor structure 99 in order to move the manipulator mechanism about the interior of the protective housing 10. The manipulator is oriented within the protective housing 10 by a pair of guide wheels 112 engaging the wall 12 of the housing. As shown particularly in Figure 12, the work platform 97 is pivoted at 114 about the vertical support member 92. A pair of lateral hydraulic cylinders 116 and 118 are remotely controllable from the drilling platform and serve to positively orient the work platform relative to the valve operator mechanism to be serviced. A second work shelf 120, essentially a duplicate of the work shelf 100, is provided for the purpose of supporting a second valve operator mechanism to be installed into the wellhead valve that is in need of service. The work platform 97 may include a television camera or other suitable apparatus for monitoring the work being done and the television camera may have the capability of panning or pivoting universally so that any work being done on any part of the housing may be monitored. Also, the work shelf itself may be capable of universal movement.

In operation, the manipulator 95 is lowered into the protective housing until the drive wheel mechanism 110 engages the annular rim of the housing. The work platform 97 is then lowered or raised by the motor 99 to the desired level of the valve operator to be serviced and the hydraulic cylinders 116 and 118 are remotely controlled in order to positively align the appropriate work shelf 100 or 120 with the appropriate valve operator. The motor 99 may also be controlled to move the manipulator about the interior of the housing for lateral alignment. The work shelf 100 or 120 is then energised causing the clamp members 102 to move into supporting engagement with the valve operator 56. The drive motor 104 and its drive socket 106 are then moved outwardly into engagement with the nut 108 of the valve operator 56 and the nut 108 is rotated by the socket 106 causing the valve operator to release its connection with the wellhead valve body. The work shelf 100 is then moved outwardly in order to extract the valve operator 56 along with the internal parts of the valve and the work platform 97 is indexed over in such manner as to align the second work shelf 120 with the valve body upon which repair is being performed. The hydraulic cylinders 116 and 118 may again be remotely manipulated in order to positively align the valve operator structure carried by the second work platform 120 with the valve being repaired. Ordinarily, misalignment will not occur by indexing, but if it does any minor misalignment can be corrected by the hydraulic alignment cylinders 116 and 118. The second work shelf 102 is then extended in such manner as to insert the internal valve parts within the valve and to move the valve operator structure into position allowing the collet clamps thereof to engage appropriate flange structure formed on the valve body.

WHAT WE CLAIM IS:—

1. A protective enclosure for a subsea wellhead apparatus, the enclosure comprising a housing of hollow cylindrical form and having a bottom end wall, a conductor guide casing secured to said end wall and a plurality of drag blades secured to the external surface of said end wall whereby when the enclosure is lowered into position in the sea bed, the enclosure may be moved so that the blades agitate the stratum of the sea bed to facilitate the positioning of the enclosure therein.

2. A protective enclosure as claimed in claim 1 in which said bottom end wall is of frusto conical form.

3. A protective enclosure as claimed in claim 2 in which said end wall is divided into two annular parts, the inner annular part being axially spaced from the outer annular part by a hollow cylindrical portion, said conductor guide casing being secured to the inner annular part.

4. A protective enclosure as claimed in any one of the preceding claims in which the housing has an outwardly extending landing flange secured thereto adjacent its end remote from said bottom end wall.

5. A protective enclosure as claimed in any one of the preceding claims including guide posts secured to the exterior wall of the housing, said posts acting to guide and locate apparatus which may be required to be inserted into the enclosure.

6. A protective enclosure as claimed in claim 4 in which the wall of the housing at said end thereof is adapted to receive and locate parts forming extensions of said wall.

7. A protective enclosure as claimed in any one of the preceding claims in which said conductor guide casing is provided with an aperture at its end remote from the housing.

8. A protective enclosure for a subsea wellhead apparatus substantially as described with reference to the accompanying drawings.

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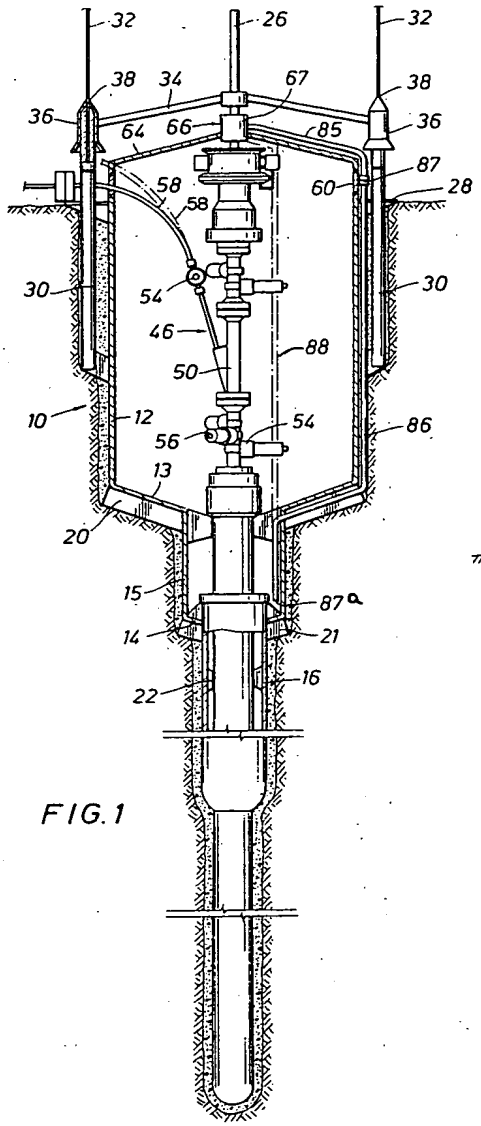

FIG. 1

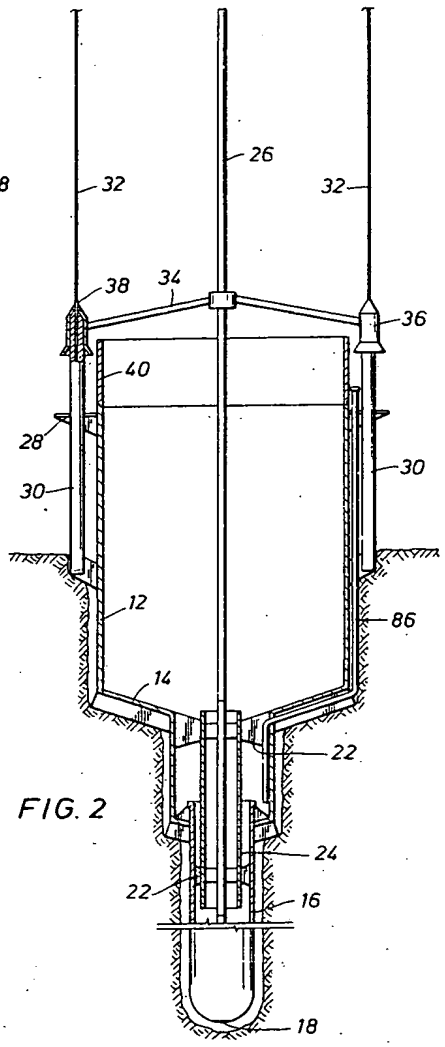

FIG. 2

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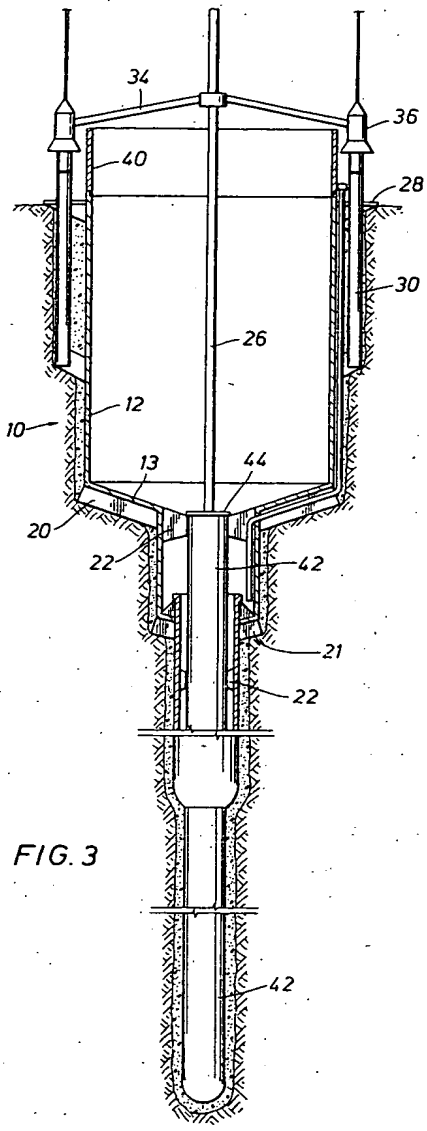

FIG. 3

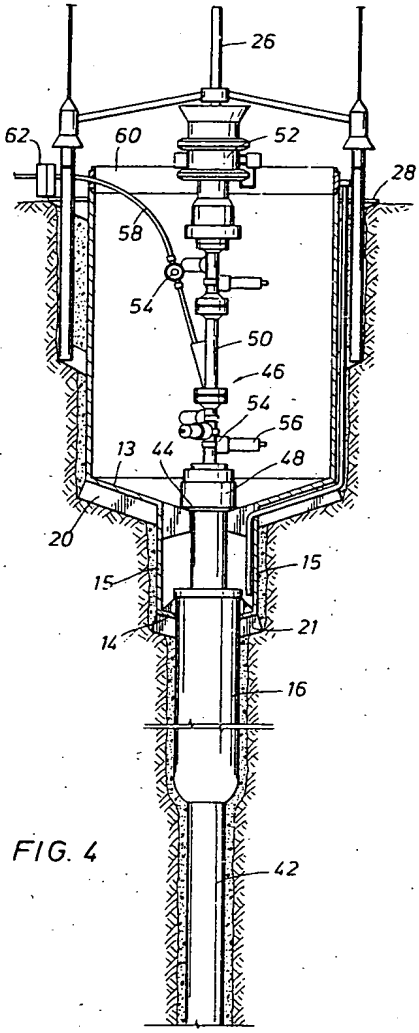

FIG. 4

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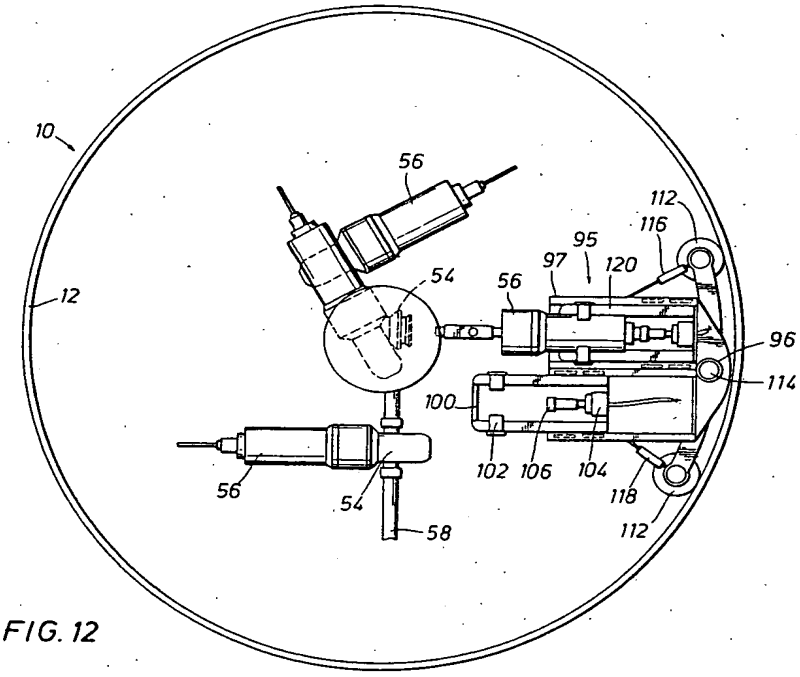
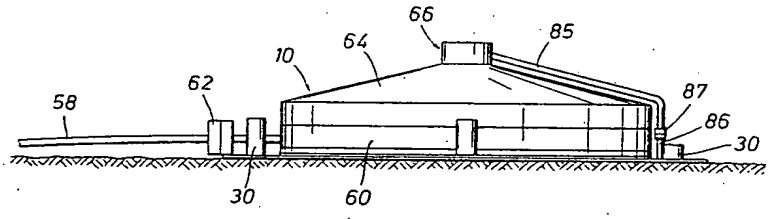


FIG. 12



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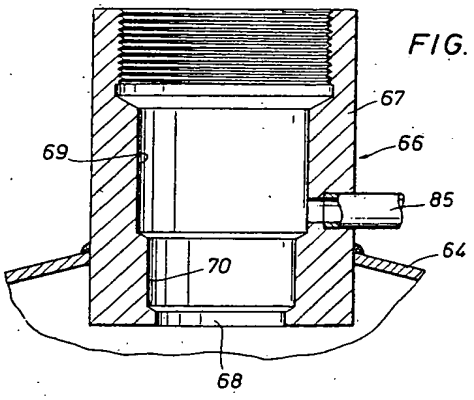


FIG. 7

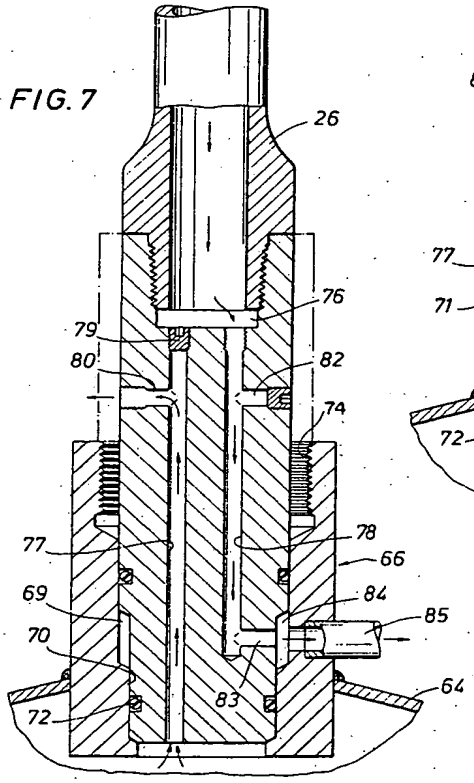
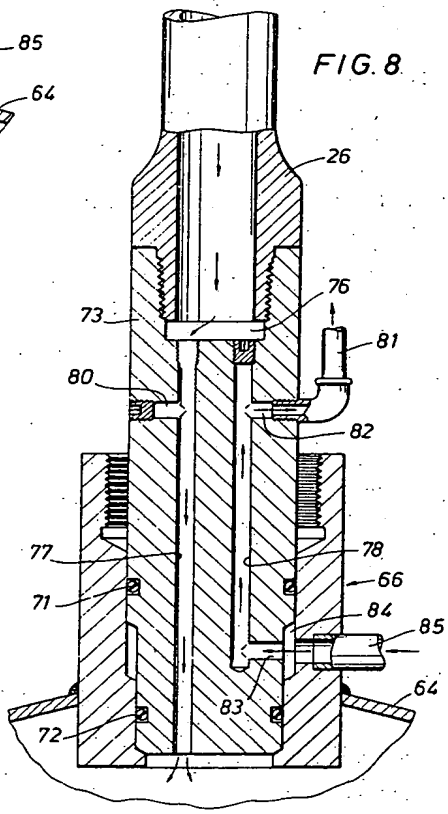


FIG. 8



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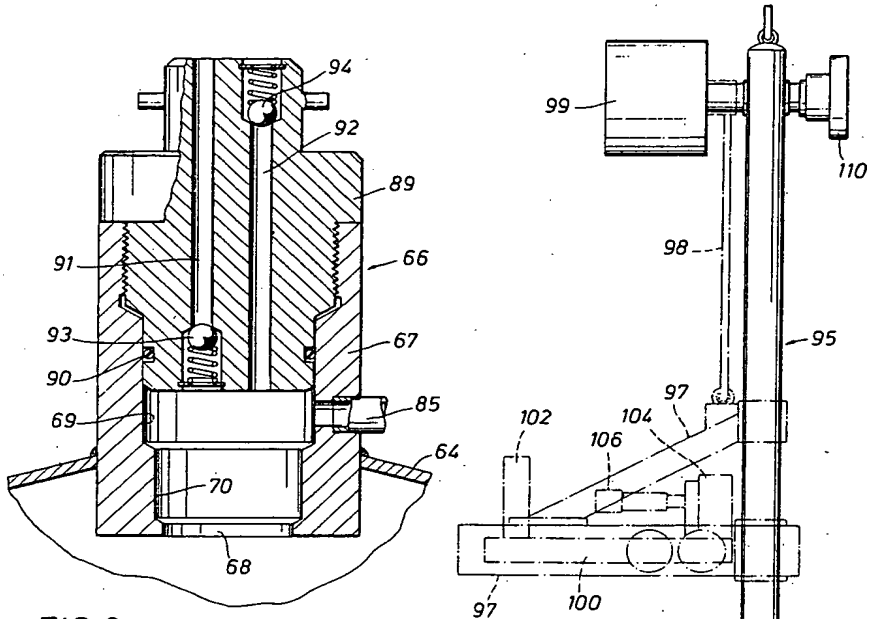
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FIG. 9

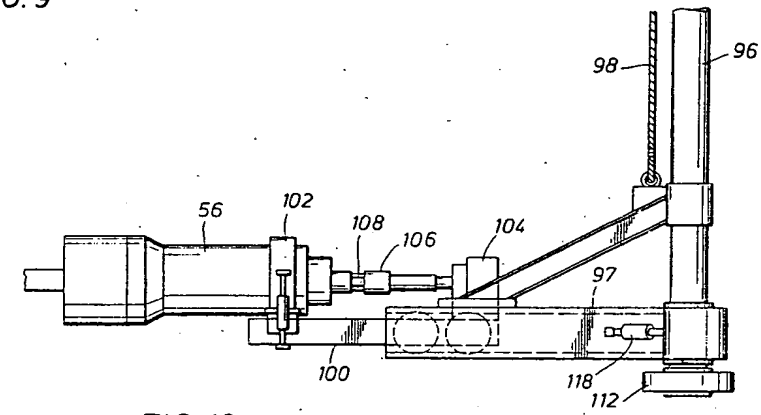
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FIG. 10

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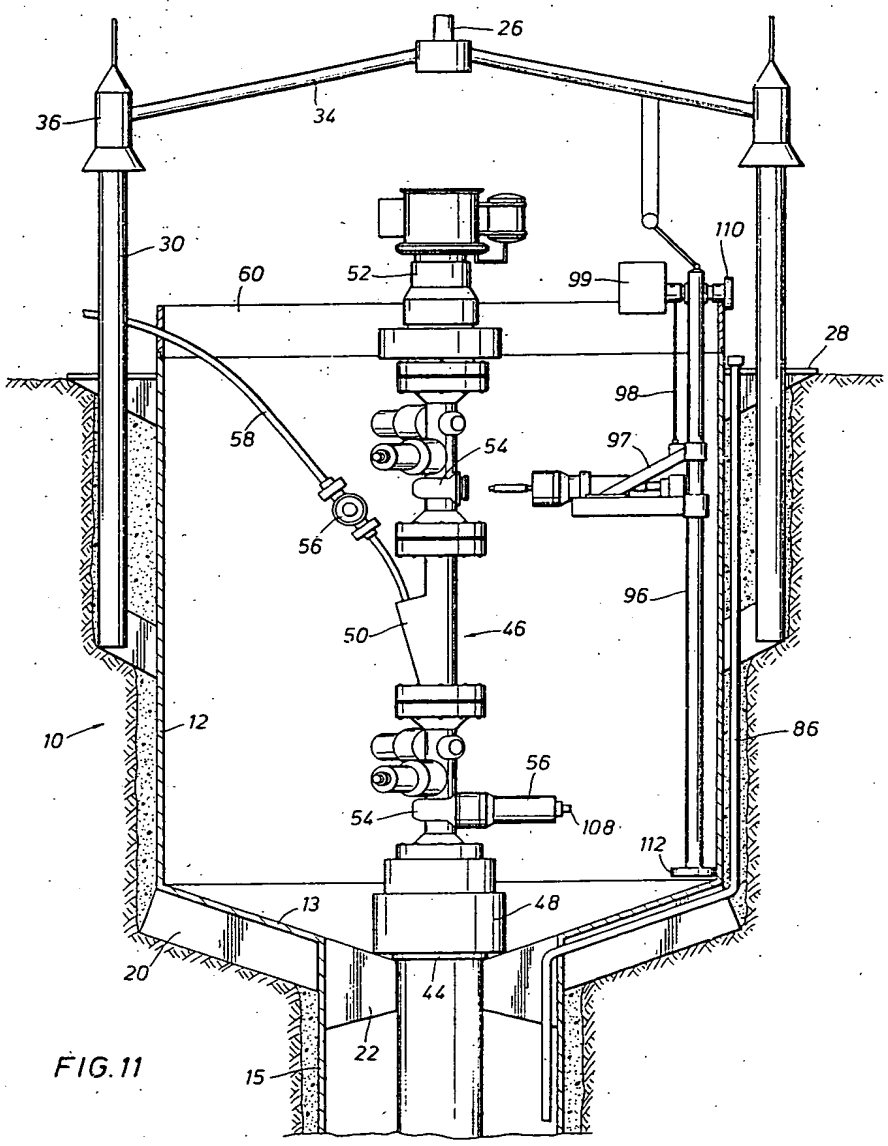

FIG. 11